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Surgical treatment of renal cell carcinoma with right atrial thrombus: Early experience and description of a simplified technique

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Abstract Operative management of patients presenting renal cell carcinoma's (RCC) with right atrial tumor thrombus extension is a technical challenge. It requires the use of cardiopulmonary bypass (CPB). The aim of this study was to report our early experience and to describe a simplified CPB technique.

5 consecutive patients underwent surgical resection by a joint cardiovascular and urological team. The ascending aorta was canulated. The venous drainage was achieved using a proximal canula inserted in the superior vena cava and a distal canula inserted in the IVC below the renal veins. Right atrium thrombus extension was extracted under normothermic CPB without cross clamping or cardioplegic arrest. A cavotomy was performed at the ostium of the renal vein and an endoluminal occlusion catheter was introduced. The thrombectomy and the radical nephrectomy were then performed. The occurrence of gaseous or tumor embolism, operative time, perioperative bleeding, and post-operative complications were assessed.

Mean patients age was 62.9 years. Atrial and caval thrombectomy were achieved successfully in all patients. Mean operative time was 206 min. Mean CPB time was 62 min. Mean hospital stay was 18.8 days. One death occurred, due to respiratory failure. An asymptomatic early thrombosis of the IVC was diagnosed by CT scan in 1 patient. The four remaining patients were alive 6 months after the surgical procedure.

Minimally invasive CPB technique can be used to treat intra atrial thrombus tumor extension arising from renal cell carcinoma. It can be performed safely with acceptable complications rate.

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Introduction

Renal cell carcinoma (RCC) extends into the inferior vena cava (IVC) as a tumor thrombus in 4 to 10% of cases.[1,2] The presence of a tumor thrombus in the IVC associated with renal carcinoma does not modify survival when total excision of the thrombus is performed and in the absence of nodal or visceral metastases.[3,4] When not treated, poor survival rates have been reported.[5]

Early experiences using different techniques evolved to date with the aim to reduce per operative morbidity. Freed and Gliedman reported the use of a balloon catheter inserted in the vana cava, and Foster et al. reported the use of caval-atrial shunt to extract tumor thrombus with success.[6,7] The surgical management of renal tumors with thrombi in the IVC has therefore become the gold standard treatment, with reported perioperative mortality rate from 2.7 to 13%.[2,8] Survival at 5 years for patients operated without preoperative metastases varies between 30 and 72%.[2,8,9,10] The short and mid-term risks if no treatment is performed are massive pulmonary embolism, total obstruction of the tricuspid valve, and liver failure as a result of the Budd-Chiari syndrome. The level of tumoral extension is based on radiological examination and trans-esophageal echocardiography (TEE). When the thrombus extends into the right atrium (level IV) cardiopulmonary bypass (CPB) is usually required. The usual approach to perform thrombus excision is CPB using deep hypothermic circulatory arrest. CPB improves surgical visibility and allows complete tumor excision, but is associated with higher overall blood loss, greater coagulopathy, longer operative times with significant increase in morbidity and mortality.[11,12] To our knowledge the use of moderate hypothermic CPB without cardioplegic myocardial arrest and without aortic cross clamping on a routine basis was not reported in the literature.

We report our early experience of level (IV) IVC thrombus extraction using a simplified CPB approach.

Materials and methods

5 consecutive patients underwent surgery for RCC and tumor thrombus extension into the right atrium. The clinical and histological characteristics are listed in Table 1.

Table 1 Clinical and histological data

Variables	
Number of patients	5
Male/female	2/3
Age average (range)	62,9 ans (37 to 79 years)
BMI (range)	25.51 Kg/m^2 (21.2 to 33.3 Kg/m^2)
Left/right kidney	3/2
Thrombus level IV	5 cases
Fuhrman grade average (range)	3.4 (3 to 4)
Clear cell adenocarcinoma	4 cases
Primitive neuroectodermal tumor	1 case
Preoperative metastases	1 case

Preoperative workup

The staging evaluation included chest, abdomen and pelvis CT scan, abdominal ultrasound with color-Doppler, and Magnetic Resonance Angiography (MRA). The MRA localized the thrombus according to the suprahepatic veins and the caval atrial junction. It also evaluated thrombus adhesion to the vein wall. The position of the upper extremity of the tumor thrombus was defined in accordance with the 4 levels described by Neves and Zincke[13] (level IV = thrombus located in the right atrium). Locoregional and metastatic extension were evaluated in all cases by brain and chest CT-scan, bone scan and hepatic ultrasound.

Surgical techniques

TEE was performed at the beginning of the surgical procedure in all patients to confirm the level of the upper extremity of the thrombus. TEE was continued throughout the operation to detect air or tumor embolisms, to localize the occlusive balloon in the IVC, and to check complete extraction of the thrombus. In all patients median sternotomy-laparotomy was performed. The IVC was exposed at the level of the renal veins and in the infra-hepatic segment. The liver was not mobilized. After systemic heparinisation (300 UI/KG), ascending aorta was cannulated. An angled venous cannula was placed in the superior vena cava (SVC), and a second angled cannula was placed above the IVC bifurcation below the renal veins. Moderate hypothermia (33 °C) CPB was initiated without cross clamping neither cardioplegic cardiac arrest. Pump flow rate was 2.4 l/min/m^2. The SVC was occluded with a Rummel tourniquet proximally to the cannula. A longitudinal right atriotomy was performed allowing the introduction of an index finger to push the thrombus into the supra hepatic IVC under TEE control. Intra pericardial IVC was then clamped for a short time, using a tourniquet. Atrial closure was achieved and the patient weaned from CPB. The renal artery was ligated. Infra-renal IVC and contralateral renal vein were clamped using a tourniquet. The patient was placed in the Trendelenburg position to decrease the risk of air embolism. A short cavotomy was performed at the ostium of the renal vein. A balloon catheter (venous catheter, size 8/22F, 80 cm long, maximum volume maximum 43 cc, Syntel, Applied Medical, Nieuwegein, NL) was introduced through the cavotomy and was inflated above the thrombus using physiological saline solution, thus performing endoluminal occlusion of the IVC. Intrapericardial IVC was then unclamped to minimize hepatic congestion. The thrombus was removed en bloc through a large, longitudinal anterolateral cavotomy, either by direct extraction or by stripping with a second occlusion balloon. A lateral cavectomy around the ostium of the renal vein was performed in all cases (Fig. 1A,B). A segmental cavectomy was performed if (macroscopic or MRA) the IVC wall was invaded by the tumor. In this setting, a 19 mm diameter expanded polytetrafluoroethylene (PTFE) graft prosthesis was implanted; the contralateral renal vein was anastomosed laterally to the graft. Extended nephrectomy was then performed. When the lumen of the vena cava presented a normal diameter, the cavectomy was closed with a non-absorbable 5.0

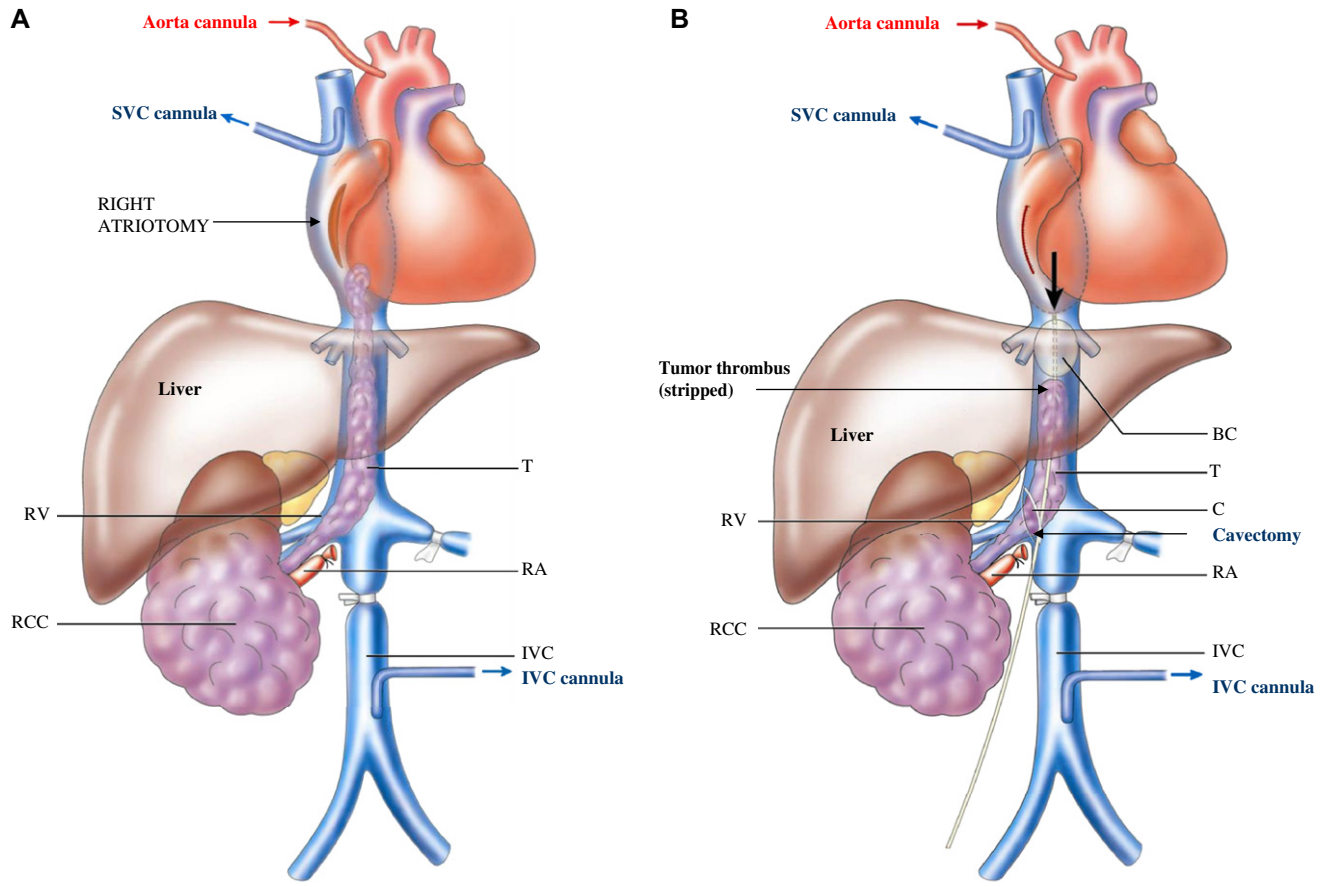

Figure 1 A: operative technique before tumor thrombus extraction, RCC: renal cell carcinoma; T: tumor thrombus; RV: renal vein; RA: renal artery; SVC : superior vena cava; IVC : inferior vena cava. B: operative technique after tumor thrombus stripping, RCC: renal cell carcinoma; T: tumor thrombus; RV: renal vein; RA: renal artery; SVC : superior vena cava; IVC : inferior vena cava; BC: ballon catheter; C: cavectomy.

monofilament polypropylene. Otherwise, the cavectomy was closed on a PTFE prosthetic patch.

In the postoperative period, all patients were admitted in the intensive care unit before being transferred to a standard hospitalization unit. A thoraco-abdominal angio-CT was performed before discharge to verify IVC patency and the absence of pulmonary embolism.

Anti-coagulation with heparin and then warfarin was initiated for a sixth month period, or for life when a prosthetic graft had been implanted.

Follow-up (serum creatinine and thoraco-abdominal CT scan) was performed and scheduled every 6 months.

Tumor staging

All tumors were classified according to the TNM classifications 2002.[14]

Assessment of the strategy

Air or tumor embolisms were assessed by TEE in the intraoperative period and by thoracic-abdominal angio-CT scans at discharge. The number of packed red cells transfused during the perioperative period was used to quantify bleeding. Postoperative complications were assessed.

Statistical analysis

Analyses were carried out using descriptive statistics (mean, range).

The survival was calculated from date of surgery to the date of death or last follow.

Results

Radical nephrectomy with tumor thrombectomy was performed in all patients.

Table 2 Perioperative data

Air embolism	0
Tumor migration (%)	0
Operative time	206 min (180 to 240 min)
CPB time	62 min (52 to 77 min)
Perioperative transfusions average (range)	9,4 packed red cells (4 to 14)
Perioperative morbidity	1 respiratory failure
Hospitalization time average (range)	18.8 (15 to 28)
Perioperative mortality	1

CPB: cardiopulmonary bypass.

Mean operative time was 206 min (180 to 240 min). CPB time was 62 min (range 52 to 77 min). CT scan diagnosed an asymptomatic early thrombosis of the IVC in 1 patient. The perioperative data are listed in Table 2.

No tumor migration and no air embolism were depicted by TEE during the intraoperative period. The average number of packed red cells transfused was 9,4 packed red cells (4 to 14). The mean intensive care unit stay was 3.6 days (range: 1 to 11 days, median 2 days), and the mean hospital stay was 18.8 days (range: 15 to 28 days). One death occurred in the perioperative period due to respiratory failure.

There were 4 renal clear cell carcinomas and one primitive neuroectodermal tumor. Four patients had total resection (R0) of the primary tumor, and 1 patient had macroscopic positive tumoral margins (R2) after surgical excision. The average Fuhrman grade was 3.4 (range 3 to 4, median 4). The tumor invaded into the perinephric fat in all cases. According to the TNM 2002 classification, the pathologic examination reported the cases as follows: pT3c ($n = 4$) and pT4 ($n = 1$). Nodal invasion was diagnosed in 2 cases. 1 patient had a unique pulmonary metastasis at diagnosis; because of the tumor thrombus extension volume into the right atrium the operative indication was maintained.

Follow-up

Four patients were still alive six months after surgery without evidence of tumor recurrence or metastases.

Discussion

Vena caval tumor thrombus extension in a RCC is a rare event. When present, 2% to 16% could have tumor thrombus extension into the right atrium.[3,8,13] The management of patients with cardiac extension (level IV) must be individualized. In our experience, nephrectomy with thrombectomy of the IVC is a procedure that can be performed without cardiopulmonary bypass (CPB), except in the setting of intra-cardiac thrombi (level IV).[8] CPB has been recommended, with or without hypothermia and cardiac arrest, for levels III and IV, because it guarantees hemodynamic stability during IVC clamping and a bloodless field.[9,12,15,16] However CPB increases the operative time, cardio-respiratory complications, postoperative bleeding, and the onset of coagulopathies.[8,17] On the other hand, digital manipulation of the tumor to push it down from the right atrium to the IVC without CPB protection may be hazardous. Hence, in the absence of effective alternative treatment, complete surgical removal of the primary tumor with its extension along the vena cava is the only available cure option. The results of our report suggest that a minimally invasive CPB technique could be used to allow extensive tumor removal in these patients.

The use of deep hypothermia CPB with circulatory arrest in patients with tumor thrombus extending into the right atrium has been reported.[18,19] Less invasive techniques using moderate hypothermia with ascending aorta cross clamping and cardioplegic arrest have also been described; in addition an occlusion balloon catheter was inserted and advanced to the level of the supraceliac aorta and inflated after the heart was arrested in order to reduce vena cava flow offering though bloodless field.[20] In our experience reducing vena caval flow was not necessary. The advantages of those techniques are: a secure operation, a bloodless field, no dissection of the retrohepatic IVC, and no occlusion of the hepatic veins. Aortic clamping is however associated with myocardial and visceral ischemia. If profound deep hypothermic circulatory arrest (DHCA) is performed, no aortic clamping is necessary. But the limits of DHCA are the associated morbidities. Indeed, this technique requires prolonged CBP for rewarming. It is also associated with increased mortality rate, neurologic complications and extensive bleeding due to platelets distortion and tumor cells autotransfusion.[21,22] Transient neurological deficits (delirium, cognitive impairment and stroke) are observed in 4% to 25% of patients.[22,23]

In our experience, moderate hypothermia CPB (33 °C), without aortic cross clamping nor cardioplegic cardiac arrest was performed. This technique does not require any clamping of neither the abdominal aorta nor the hepatic veins. Stewart et al. reported their experience in which cardiac arrest was not used. Nevertheless, the investigators reported the use of vena cava interruption and satisfactory visualization despite blood loss from the hepatic veins which we did not observe.[24] Thus our approach is safe, easy to set up and simple to use. It maintains peripheral perfusion and avoids the major inconvenients related to CPB listed above in the previous reports.

Liver mobilization and transdiaphragmatic approach was not necessary in our experience to perform safely (under TEE monitoring) a complete caval thrombectomy. This approach therefore reduces the risk of per operative embolism. Tomita et al., using intraoperative TEE monitoring, reported an increase risk of embolism migration during liver mobilization.[25] A complete caval thrombectomy was performed successfully in all patients. In all cases, the tumors were slightly friable allowing en bloc extraction. This technique did not lead to any major complications and was controlled by TEE monitoring. It also allowed performing a segmental resection and reconstruction of the IVC in cases of adherent thrombi. It can be recommended as first choice technique for renal cell carcinomas with atrial thrombus. However these tumors could be voluminous and adherent. In that case our technique could be unadapted. In our experience this was not observed.

Intra and perioperative parameters (embolism, bleeding, transfusion…), in our series, compare favorably with other reported series.[8,17,26] In our series, CPB time was short, as well as supra hepatic IVC clamping, thus avoiding hepatic congestion which was not encountered. However, if the IVC clamping has to be prolonged, a Pringle maneuver could be achieved. Two-dimensional intraoperative TEE is a non-invasive technique providing to both surgeon and anesthetist significant informations.[27,28] It confirms the exact position of the thrombus accordingly to the preoperative workup. In addition it provides informations regarding retrohepatic IVC parietal invasion. In our study, there was no difference between the pre- and per operative position of the thrombi. All the tumors treated were not adherent and did not invade the IVC wall. The TEE probe was introduced shortly after the anesthetic induction and left in place throughout the procedure in order to detect any tumor or air embolisms, localize the

endoluminal occlusive balloon in the free IVC above the thrombus, and verify that the thrombus has been completely excised. An additional advantage of TEE is its accuracy for anesthetic monitoring; it can replace a Swan-Ganz pulmonary arterial catheter, monitor the ventricular function and the mobility of the cardiac wall and septum, and study the cardiac valves. In our experience, TEE was always used. We believe it has advantages at every stage of the procedure.

The CPB approach described in this paper offers several advantages. First, cerebral perfusion is maintained through out the procedure. The morbidity related to DHCA and aortic cross clamping is avoided. Complete resection of the tumor was always performed, without tumor or air embolism, and minimum blood loss. Hemodynamic stability and avoiding vital organ ischemia were always achieved during the procedure.

Conclusion

A simplified CPB technique with neither hypothermic circulatory arrest nor cardioplegic cardiac arrest can be performed in the surgical treatment of intra atrial thrombus tumor extension arising from renal cell carcinoma. It can be performed safely, effectively and can result in acceptable complications rate. This technique can be recommended as first choice technique for renal cell carcinoma with intra atrial thrombus extension.

Conflicts of interest
None.

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None.

Ethical approval
Not required.

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